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RUSH S. DRAKE ASSOCIATES
Electronic Sales Engineers
6133 MAYNARD AVENUE SOUTH SEATTLE 8, WN.
PARKWAY 5-2700

DONNER

DIVISION OF SYSTRON-DONNER Corporation

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Instruction Manual

Model 2102

WAVE ANALYZER

DONNER SCIENTIFIC COMPANY

Concord, California

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SYSTRON-DONNER Corporation

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RECEIVING INSPECTION

Every Systron Donner instrument is carefully inspected and is in perfect working order at the time of shipment. Each instrument should be checked as soon as received. If the unit is damaged in any way or fails to operate, a claim should immediately be filed with the transportation company.

REPAIRS

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Please specify both model and serial number in all correspondence concerning Systron-Donner instruments. Address all inquiries on operation or applications to your nearest sales representative or Sales Manager, Instruments, Systron-Donner Corporation, 888 Galindo Street, Concord, California.

GENERAL DESCRIPTION

The Donner Model 2102 Wave Analyzer is a frequency-selective vacuum-tube voltmeter which accurately measures relative amplitude and frequency of harmonic components in a complex waveform. Input signals between 15 microvolts and 600 volts in amplitude in the frequency range of 30 cps to 50 kc may be measured. The wave analyzer may be used for measuring harmonic and intermodulation distortion, for hum and noise analysis, and for applications requiring a frequency-selective voltmeter.

The Model 2102 employs a heterodyne circuit with a sharply-tuned IF amplifier containing crystal filter coupling networks to obtain fixed-frequency, constant-bandwidth amplification. Narrow or broad selectivity is provided with 40 db attenuation at $\pm$40 cps or $\pm$125 cps respectively. The selected input frequency is read directly on a front-panel tuning dial. Output of the selective IF amplifier, expressed in decibels or as a percentage of a reference level, is indicated on a precise vacuum-tube voltmeter. Front-panel controls are provided for input attentuation (coarse and fine), tuning (coarse and fine), oscillator calibration, modulator balance, filter bandwidth, and meter range. The meter range switch permits upper scale readings, for improved linearity, of input signals as low as 75 microvolts.

SPECIFICATIONS

Range of Frequency Measurements:
30 to 50,000 cps.

Frequency Calibration:
± (3% plus 10 cps).

Voltage Range:
Full scale meter indication for signal voltages from 160 microvolts to 500 v.

Lowest Usable Readings:
Approx. .03% (-70 db).

Voltage Accuracy:
± 5% of full scale reading.

Residual Modulation Products:
Suppressed approximately 70 db.

Hum and Noise:
Approximately 70 db below 100% (0 db) level.

Selectivity:
Narrow -3 db down at ± 9 cps, 40 db at ± 40 cps.
Broad -3 db down at ± 20 cps, 40 db down at ± 125 cps.

Input Impedance:
200,000 ohms.

Power:
115/230 volts 50-1000 cps, 45 watts.

Cabinet Dimensions:
16-1/2" wide, 11" high, 10-1/2" deep.

Weight:
24 pounds (net); 29 pounds (shipping).

THEORY OF OPERATION

Figure 1 shows a functional block diagram of the instrument. The amplitude of the input signal which is to be analyzed is set to the reference level by the input attenuators. The input signal is then fed through a cathode-follower stage which isolates the input circuit from the rest of the instrument and provides the necessary impedance transformation to the balanced modulator. A tunable local oscillator, whose frequency is controlled by the main tuning dial, operates below the IF frequency. Thus, the signal component being measured has its frequency transformed to the IF frequency and is amplified and measured at this fixed frequency. Other frequency components present in the input signal are transformed to other frequencies which are rejected by the two half-lattice crystal filters.

OPERATION

Installation

The Model 2102 should be located in an environment which ensures good ventilation. Care should be taken with input leads to avoid picking-up stray fields and hum voltages since the instrument has high gain and high input impedance.

Warm-up

To place the Donner Model 2102 in operation, set the METER RANGE switch to the SET-LEVEL position, turn the power switch ON, and allow at least fifteen minutes for warm-up.

Oscillator Calibration

With no input signal applied and the selectivity switch at "narrow", set the main tuning dial to zero and the FINE TUNING knob to the index mark on the panel. Carefully rotate the CALIBRATE knob until maximum indication is obtained on the meter. This procedure adjusts the frequency of the local oscillator to 395 kc so that the tuning dial calibration will indicate correctly the frequency of input signal components under measurement.

Balancing

Next, carefully rotate the BALANCE control knob for a minimum reading, readjusting the CALIBRATE knob for a maximum if necessary. The minimum reading should be well below the INPUT LEVEL mark on the meter when the METER RANGE switch is in the SET LEVEL position.

This balancing operation nulls out the local oscillator signal appearing in the balanced modulator output so that the carrier signal will not interfere with measurement of low frequencies or tend to overload the crystal filters or the IF amplifier stages. The small residual reading is due to minute fluctuations in line voltage and frequency.

Narrow and Broad Selectivity

Either the NARROW or BROAD position of the selectivity switch may be used. The BROAD position is advantageous when tuning rapidly over the spectrum or when the signals have a small amount of frequency instability, such as those from the reproduction of a recording. The NARROW selectivity position is preferred for improved measurement accuracy when signal components are spaced relatively close together. If changing from broad to narrow selectivity during a measurement, re-adjust the FINE tuning control for maximum indication on the meter.

Tuning and Measuring

The instrument is now ready to measure the spectrum components of input signals. Set the reference level as follows:

1. With the METER RANGE switch in the SET LEVEL position, apply a signal to the input terminals and tune the instrument over its entire frequency range to find the input signal component having the largest amplitude. (This is usually the fundamental if a single source of signal is present.) The FINE TUNING control may be used to facilitate tuning to the desired frequency; however, if accurate frequency calibration is desired, it should be re-positioned to its index mark.
2. Adjust the input level attenuators so that the panel meter reading corresponds to the INPUT LEVEL mark.
3. Turn the METER RANGE switch to the 100% (O db) position and re-adjust the fine input attenuator control, if necessary, for an exact reading of 100%. This signal level will remain the O db or 100% reference level as long as the input attenuators are not disturbed.

The main tuning dial may now be adjusted to select the other signal components for measurement of their frequency and amplitude. For these measurements the METER RANGE switch should be set so that the meter reading at resonance (maximum deflection) falls between O db and -10 db. Percentages may be read directly on the appropriate meter scale, and db readings will be the sum of the markings on the meter scale and the METER RANGE switch.

If the reading falls on the lower portion of the -50 db meter scale, a better indication can be obtained by advancing the Coarse input attenuator switch 1 position clockwise while, at the same time, changing the Meter Range to -40 db. The actual meter scale will now be -60 db and readings can be made in the upper portion. Do not touch the Fine input attenuator.

Direct-Reading Voltmeter

If it is desired to use the instrument as a direct-reading selective voltmeter, a reference signal level corresponding to a known voltage may be used to establish the gain of the instrument. This is done by tuning the wave analyzer to resonance with a sine-wave signal source of known amplitude such as an audio oscillator or a 60 cps filament supply. The input attenuators are then adjusted so that the meter reading bears a convenient ratio to the known signal voltage. For example, 60% might correspond to 6 volts rms. The instrument would then be operated in the normal manner with the chosen ratio applying to all readings, provided that the input attenuators were not disturbed. Care should be taken to avoid overloading the balanced modulator stage with signals exceeding the 100% level. The effect of such overloading would be to exceed the linear operating range of the modulator, thus generating nonlinear distortion products.

CIRCUIT DESCRIPTION

(Refer to schematic diagram, Dwg. no. 4024.)

The Input Attenuator consists of a coarse fixed-resistor divider network (R1 through R4) which reduces the input level in 20 db steps, and a fine potentiometer attenuator (R5) which selects the precise voltage required for the "Set Level" adjustment. The signal from the input attenuator is coupled through C2 to a low-distortion cathode-follower input stage.

The Local Oscillator (V7) is a modified electron-coupled Colpitts oscillator, known as a Clapp circuit. Load variations caused by the action of the modulator circuit do not affect the oscillator frequency. The sensitive components of the tuned circuit are enclosed in a shielding compartment. Capacitors C36 and C37 are compensating capacitors of different temperature coefficients. The effective temperature coefficient required to maintain optimum thermal stability is determined by the adjustment of capacitor C38. A filter network, consisting of C24, C25, L9 and L10, provides decoupling and isolation of the oscillator output from the rest of the circuitry.

The Modulator Stage uses a type 6AL5 duo-diode (V2) connected as a series-balanced modulator, as shown in simplified form in Figure 2. The oscillator output is coupled through Transformer T2 to the series diodes. When the Balance control (R39) is properly adjusted, no voltage of oscillator frequency will appear in the primary of T1. Capacitor C22 is adjusted for capacitive balance between the two diode sections.

An input signal impressed on the circuit through capacitor C4 will raise or lower the voltage at the wiper contact of R39, causing one diode section to conduct more than the other. Current at the oscillator frequency then flows through the primary of T1, inducing a voltage in the secondary winding. The input signal modulates the carrier, therefore, by controlling the amount of current at the oscillator frequency coupled into the primary of T1. The modulated voltage at the secondary of T1 contains sum and difference frequency components of the oscillator and input signals. The input signal itself is not transmitted through T1.

Crystal Filters: The two crystal filters are designed to pass a 395 kc signal representing the sum of carrier and input frequencies. All other frequency components, including the carrier and lower sideband, are rejected.

An equivalent circuit of the crystal filter is shown in Figure 3, wherein the crystals form two arms of a bridge network. Each crystal behaves electrically like the portion of the circuit shown within dotted lines, having both series and parallel resonance properties. The small d-c resistance of each crystal is disregarded for the purposes of the following discussion.

The behavior of the overall circuit may be understood by reference to the reactance vs. frequency graph of both crystals given in Figure 4. The series-resonant frequency of crystal B, designated S_b, corresponds to the parallel-resonant frequency of crystal A, designated P_a. The attenuation of the filter, shown by dotted lines in Figure 4, is maximum at the two frequencies, $-X_{ab}$ and $+X_{ab}$, at which the reactances of both crystals are equal. At these two frequencies, both arms of the bridge circuit are balanced and no current flows through the load resistance. Attenuation decreases from $-X_{ab}$ until is theoretically zero at the series-resonant frequency of crystal A designated S_a. Between frequencies S_a and P_b the reactances of the crystals are of opposite sign and attenuation remains approximately at zero. The frequency range lying between these two points represents the bandwidth of the filter. At frequencies immediately above or below the band-pass range the impedances of both crystals rise sharply consequently reducing the signal across the output load resistance.

In the "broad" position of the ganged selectivity switches (S2 and S4), an 1800 ohm resistor is placed in series with each crystal to reduce the effective Q of the filters. Variable capacitor C10 is used to equalize upper and lower skirt selectivities at both "narrow" and "broad" positions of the selectivity switch while R16 is adjusted to equalize gain.

The Meter Range Switch is a precision attenuator at the input of the IF which adjusts the gain of the system to a known multiple of the gain established during the "Set Level" adjustment. It is located at the input to the IF amplifier to permit the amplifier to operate at nearly the same signal level for all measurements. Range adjustment in 10 db steps permits the use of the upper half of the meter scale for most measurements. As a result, linear operation of the IF amplifier and of the meter is insured. The "Set Level" position of the switch corresponds to maximum attenuation and is used to establish the 100% reference level for the frequency component of greatest amplitude.

The IF Amplifiers: The signal from the meter range switch is amplified by the pentode section of V3, a single-tuned amplifier. The triode section of V3, connected as a cathode follower, provides a low-impedance drive for the second crystal filter. This filter, identical to the first, provides additional selectivity. After further amplification by V4, another tuned amplifier, the signal voltage is measured by the vacuum-tube voltmeter circuit.

The Vacuum-Tube Voltmeter has two stages of amplification. Negative feedback from the meter movement is returned to the cathode of the pentode section of V8, improving linearity of the meter indication. The triode section of V8 is coupled through C42 to a full-wave rectifier which drives the meter through a filter consisting of L11, L12, C45, C46, and C43.

The Plate Voltage Supply is a standard full-wave rectifier circuit followed by a capacitor-input filter and a type OA2 voltage regulator tube to reduce the effects of supply line voltage variations.

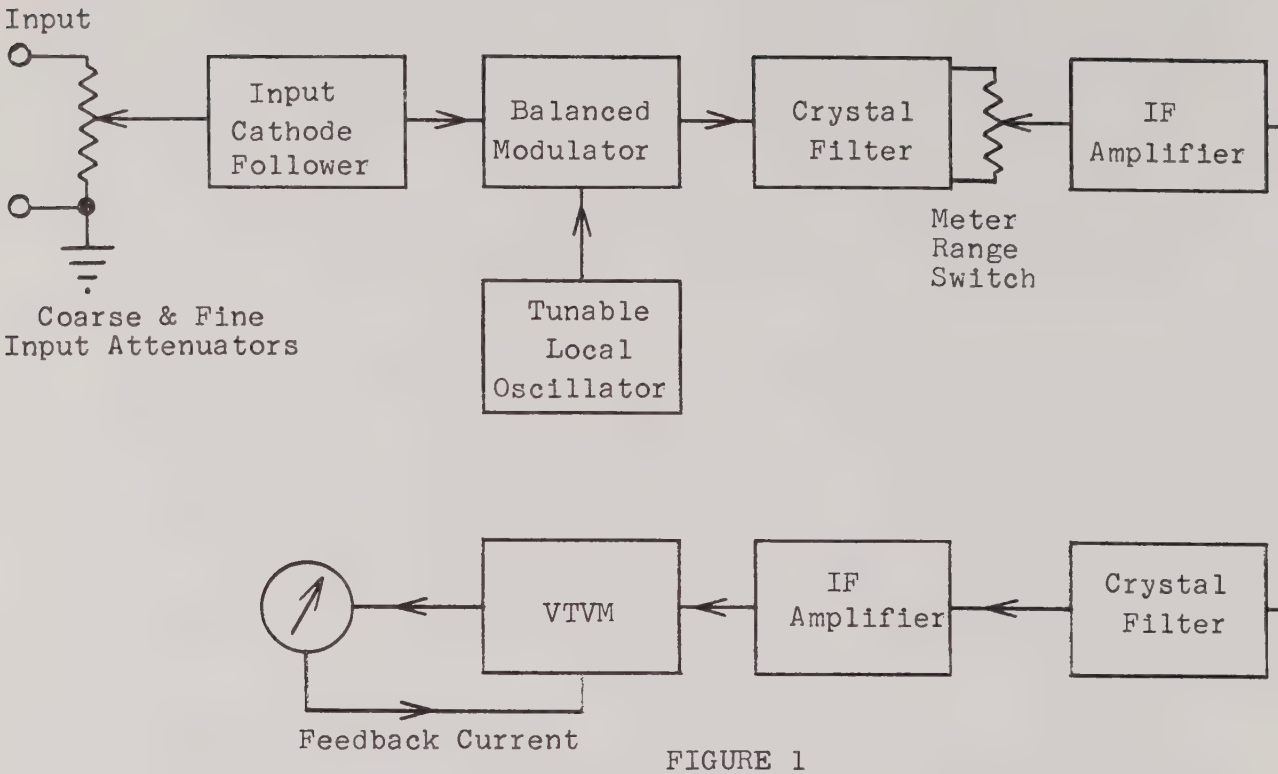


FIGURE 1

Functional Block Diagram Of Model 2102 Wave Analyzer

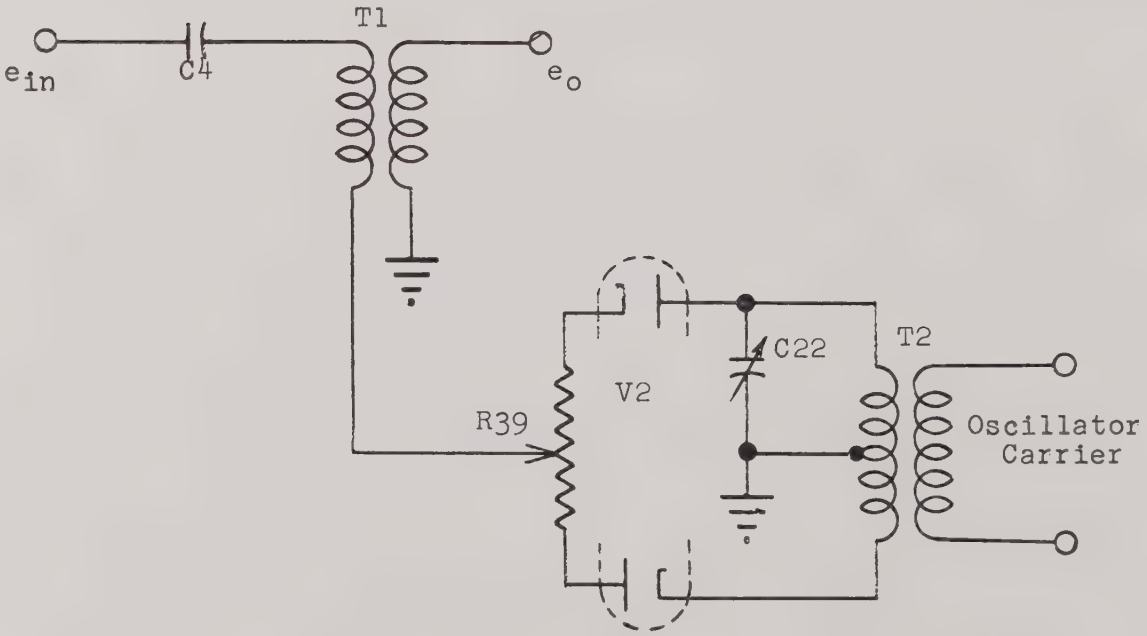


FIGURE 2

Simplified Diagram Of Balanced Modulator Stage

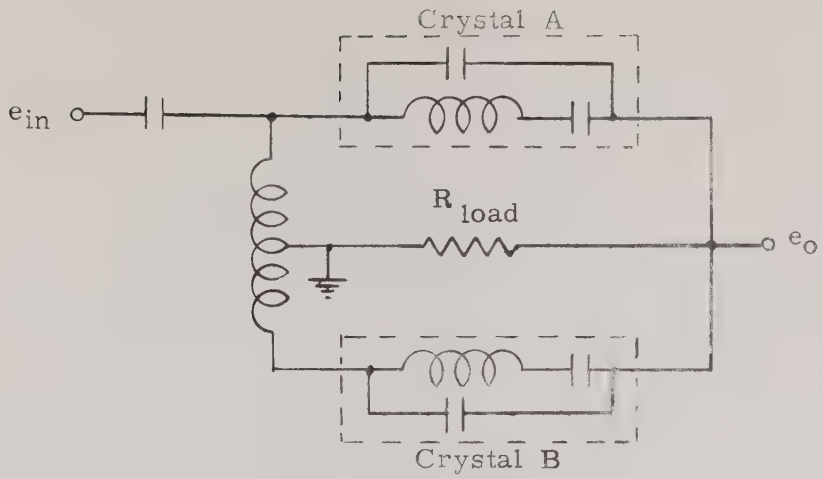


FIGURE 3

Equivalent Circuit of Crystal Filter

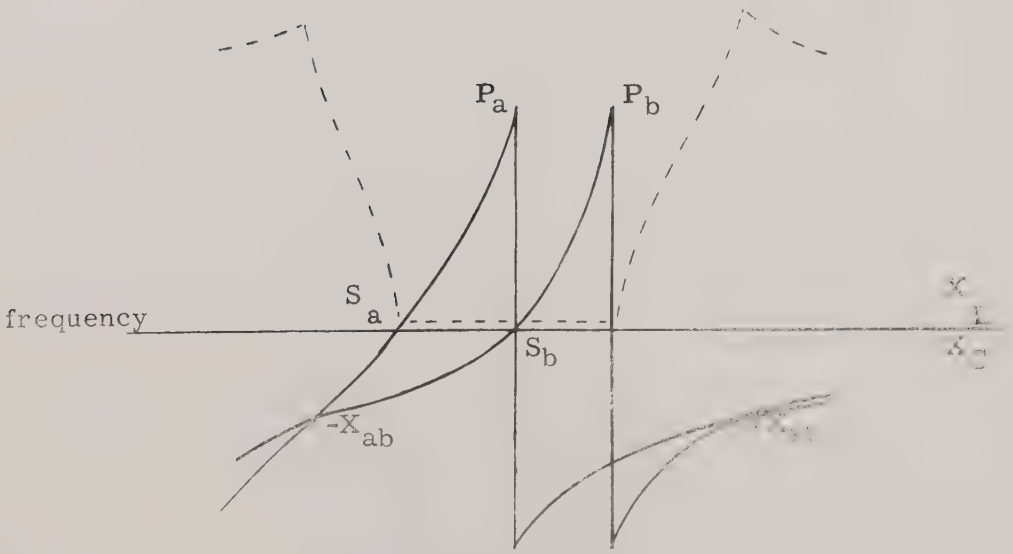


FIGURE 4

Reactance and Attenuation vs. Frequen
Of Crystal Filter

The tests given below will determine the correct operation of the Model 2102 Wave Analyzer. The complete procedure for re-alignment, if necessary, is given at the end of this section. Test equipment required for the procedures covered in the Servicing section include the following:

Audio signal generator
RF signal generator
Frequency counter
Vacuum tube voltmeter

Tracking

1. With the main tuning dial at zero and the Meter Range switch at "Set Level", adjust the Calibrate control for maximum output.

2. Apply a 1000 cps input signal. Tune in sequence to the fundamental and all harmonics up to 10KC and note the settings of the dial at which each frequency component appears. (Harmonics may be generated by setting the input attenuators in a low range to introduce distortion).

3. Change to a 10KC input and note the dial settings for all harmonics up to 50KC. All readings in steps 2 and 3 should fall within ± 3% of correct values. If not, refer to "Oscillator Alignment".

Sensitivity

1. Place the Meter Range switch at "Set-Level" and both input attenuators at maximum (clockwise).

2. Tune the Model 2102 to any input signal and measure the level of signal necessary to produce a center-scale reading on the meter. It should be no more than 25 millivolts. Low sensitivity indicates faulty alignment or tubes.

Frequency Response

Insert successively several input frequencies of the same amplitude between 30 cps and 50KC. Tune the wave analyzer to each. The meter reading should not vary more than ± 5% through the full range of frequencies.

Oscillator Bias

Measure the bias on pin 1 of the 6AG5 oscillator tube (V7). It should be at approximately -1.5 volts. Insufficient bias may indicate a defective oscillator tube.

B+ Voltage

The B+ voltage, measured at pin 5 of V6 should be +150 (±10) volts.

Hum

1. Short the input terminals of the Model 2102.

2. Adjust the Balance control for minimum output with the dial set at zero.

3. Place the selectivity switch at "narrow".

4. Measure the levels of 60 cps and 120 cps components. Their values should not exceed -60db. If greater than this amount, replace the 6ES8 tube or check components in the power supply.

Harmonic Distortion

1. Apply a low-distortion, 1000 cps signal of which the levels of second and third harmonics are known.

2. Adjust the amplitude of the fundamental for 100% in the Set-Level Position.

3. Measure the level of second and third harmonics. These amplitudes should not differ from the known levels by more than ±5%. High Harmonic distortion may indicate low IF sensitivity or a defective input or modulator tube (V1 or V2).

Selectivity

a. Gain Adjustment: Tune to any input signal in both narrow and broad band selectivity. Meter readings should be the same. If not, adjust R16 in the narrow position for equal gain.

b. Bandwidth and Symmetry

   1. Tune to a 300 cps input signal, set selectivity to "Narrow", and adjust the level of signal for 100%.

   2. Change the input signal ± 50 cps with the Model 2102 still tuned to 300 cps. The output amplitudes at 250 and 350 cps should be equal and approximately -65 db. If not, adjust C10.

c. Crystal Check

1. Re-tune the input signal to 300 cps and adjust the input attenuators for a midscale reading in the 100% position.

2. Change the meter scale to 1% (-40 db).

3. Vary the input frequency above and below 300 cps to obtain a mid-scale reading again and note the frequencies at which this occurs. Bandwidth should be no more then ± 45 cps in "narrow" and between ± 125 and 180 cps in "broad".

Some variation in narrow selectivity may be obtained by adjusting C10. A compromise adjustment may be required to optimize the symmetry and selectivity. Insufficient selectivity or unsymmetrical response may indicate defective crystals or ovens. Some adjustment of the symmetry may be obtained by re-tuning L2 or L4.

Attentuators

a. Meter Range Switch

1. Insert a test signal and adjust the input attenuators for a mid-scale reading in 100% position.

2. Without changing the input attenuators, decrease the amplitude of input signal in precise steps of 10db while, at the same time, rotating the Meter Range switch clockwise in 10db steps. Meter readings should not vary more than ± 1/2 db in each position. Error may be caused by regeneration in the IF amplifiers or the vacuum-tube voltmeter circuit, or by change in resistance values of R20 through R26. Regeneration may also be noted as a loss of agreement between readings in narrow and broad selectivity at high sensitivity settings of the Meter Range switch.

b. Input Attenuator

1. Set the Coarse input attenuator at 0 db, the Fine attenuator at maximum, and the Meter Range switch at 100%.

2. Adjust the input signal amplitude for a mid-scale reading. (Do not disturb the Coarse control for this adjustment.)

3. Simultaneously move both the Coarse attenuation and Meter Range switches in steps of 20 db. Meter readings should agree within 5% at each step.

ALIGNMENT PROCEDURE

Oscillator Alignment

a. Setting the Dial: With the main tuning capacitor plates fully meshed, the panel index mark should be 1/4 inch beyond the 50KC mark on the dial. Refer to the Tracking test. If there is a constant error at all readings between 1 KC and 10 C, re-alignment of the dial is necessary. Loosen the set screw at either end of the flexible coupling on the tuning shaft. Turn the dial for the correct indication and tighten the set screw again.

b. Calibration:

1. Set C34 (trimmer capacitor in the main tuning compartment) for 50% rotation. Turn dial to 50KC.

2. Adjust L8 to obtain an output of 345KC measured on a frequency counter connected to one of the secondary leads of T2.

3. Turn the dial to zero. Adjust C34 and/or C31 for an output of 395KC.

Refer to the tracking test. If there is an increasing error noted at successive readings between 10KC and 50KC, continue with the procedure.

4. Turn the dial to 30KC. Adjust L8 for an output frequency of 365KC.

5. Readjust C34 and/or C31 for an output of 395KC with the dial at zero.

6. Repeat steps 4 and 5 until both points track without readjustments.

7. With dial at zero and Calibrate and Fine Tuning controls at center of their rotation (index mark on each knob is vertical), adjust C34 for a reading of 395KC on the frequency counter. The Calibrate control will now have the proper range.

8. Disconnect the frequency counter and adjust the tuning slug of T2 for maximum DC bias on pins 5 and 7 of V2, the modulator tube. This bias should be approximately +2 and -2 volts, respectively.

General Alignment

The following steps cover alignment of all remaining stages in the Model 2102 after the oscillator has been aligned or tested.

1. Set the selectivity switch at "broad", the tuning dial at zero, and the meter range switch at "Set Level". Adjust the Calibration control for a maximum meter deflection. If no output is observed, de-tune the Balance control.

2. Turn the tuning slug on modulator transformer T1 for maximum deflection. Next, adjust L3 and L5 for maximum output reading.

3. Balance the modulator by adjusting the Balance control alternately with with C22 for a minimum reading while, at the same time, keeping the Calibrate control adjusted for maximum.

4. For final alignment, feed in an input signal of approximately 1000 cps and tune the dial to it. Adjust the attenuator for mid-scale deflection in the "Set Level" position. Next, align the components for maximum meter deflection in the following order: L5, L3, T1, L2, and L4. L2 and L4 are tuned broadly. It is usually sufficient to set the tuning slugs at the midpoints of their ranges.

5. Turn the Selectivity switch to "narrow" and retune if necessary. Adjust R16 for the same meter reading as in the "broad" position.

6. Check the alignment of the Model 2102 by making the sensitivity and harmonic distortion tests.

TROUBLE-SHOOTING

Besides the defects which may be revealed by the foregoing test procedures, some more general symptoms which appear may be isolated by use of the following outline.

A. No output during calibration (with no input signal)

1. Check power supply voltage. If the VR tube (V6) glows, the voltage is present.

2. De-tune the Balance control to verify presence of oscillator signal.

3. Switch to "broad" selectivity. If output is present, alignment, filters, or switch is defective.

4. Try other positions of the Meter Range switch to confirm continuity or low oscillator output.

5. Replace tubes, beginning with the oscillator stage (V7).

6. Check the meter by measuring across its rear terminals with an ohmmeter.

7. Re-align the oscillator and/or IF stages.

8. Signal trace with an oscilloscope or a-c voltmeter, using a .01 mfd. capacitor in series with the test lead. Set the tuning dial at zero and the Meter Range switch at 0.3%. First observe or measure the oscillator output at the plate (pin 5) of V7. Proceed by testing at the input and output of each succeeding stage.

9. Typical tube pin voltages are given on Page 16.

B. Will not balance

1. Replace V2.

2. Re-align C22 (Refer to step 3 of general alignment procedure.)

3. Check continuity and balance of transformer T2 secondary.

4. Check R40 and R41.

C. No output with input signal (Calibration adjustment is all right).

1. Replace V1.

2. Couple input signal through a 0.1 mdf. capacitor directly to grid (pin 7) of V1 in order to by-pass attenuators.

3. Check C4.

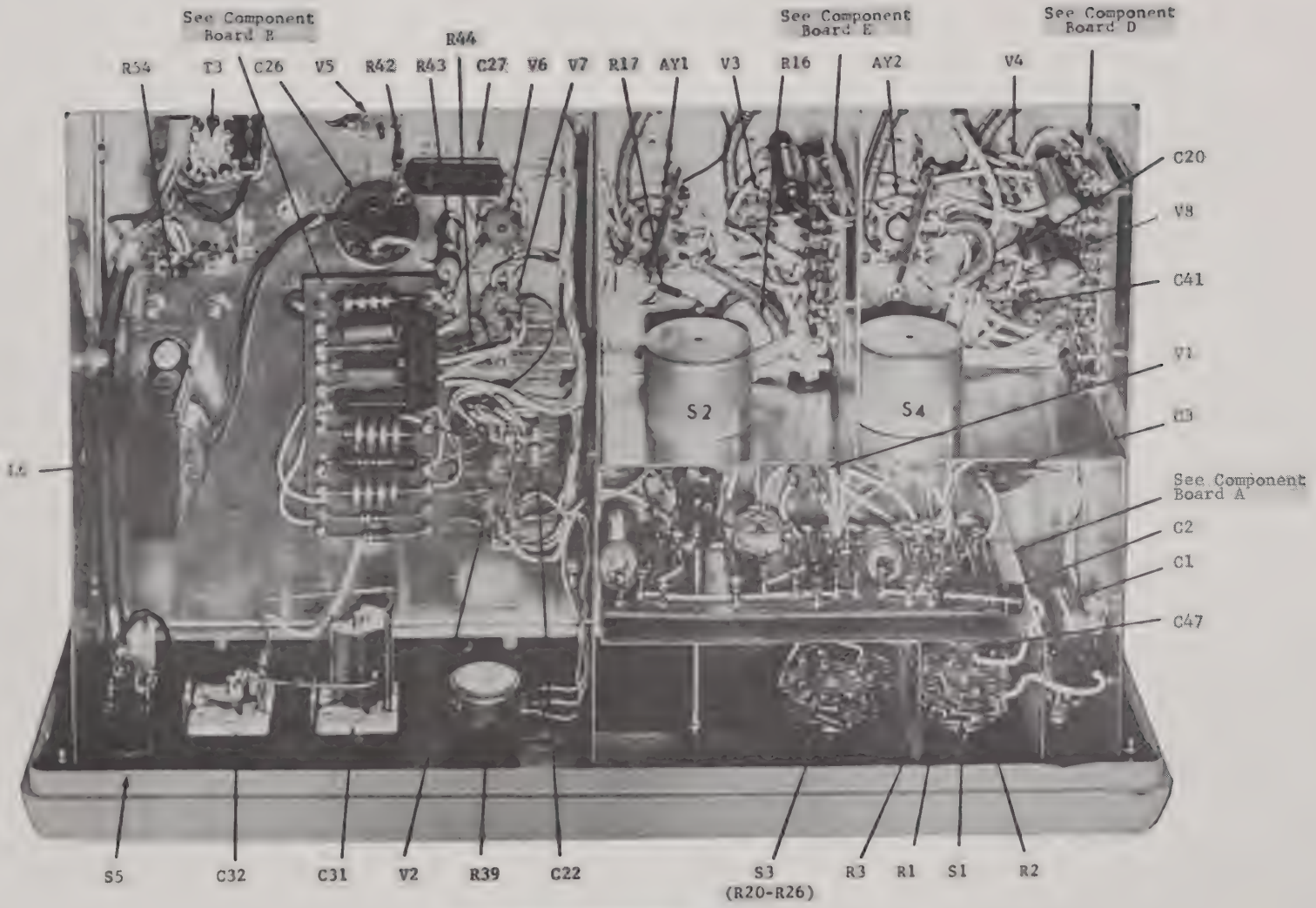


Figure 5A Parts Location

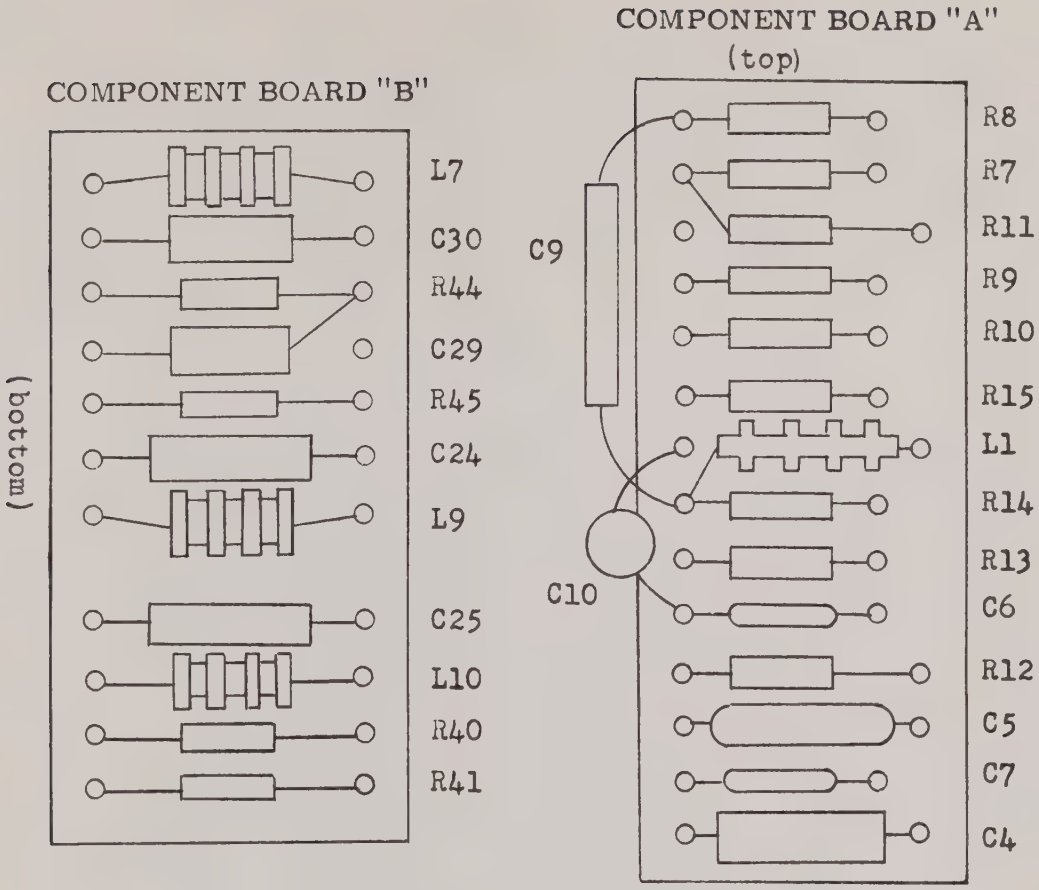


FIGURE 5B
Parts Location

DC VOLTAGE CHART

The typical tube pin voltages given in this chart were taken with a vacuum tube voltmeter and with the Model 2102 adjusted for the following preliminary conditions: (1) selectivity at narrow, (2) Set-Level meter position, (3) oscillator calibrated, balanced, and then tuned above 1KC, (4) zero input signal. All voltages are positive unless otherwise noted.

	Tube Pins								
Tube	1	2	3	4	5	6	7	8	9
V1 6ES8	150v	36v	37v			145v	34v	35v	
V2 6AL5	0.1v	-0.1v			1.55v		-1.55v		
V3 6U8	95v	0v	95v			+95v	1v	25v	30v
V4 6AU6	0v	1.2v			115v	115v	1.2v		
V5 6X4							295v		
V6 OA2	150v	0v			150v				
V7 6AG5	*	0.3v			1 45v	110v	3v		
V8	-8v	68v	0v			85v	44v	2v	1.3v

* Varies with dial setting. Approximately -0.1 volts at zero. - 1.5 volts at 50KC.

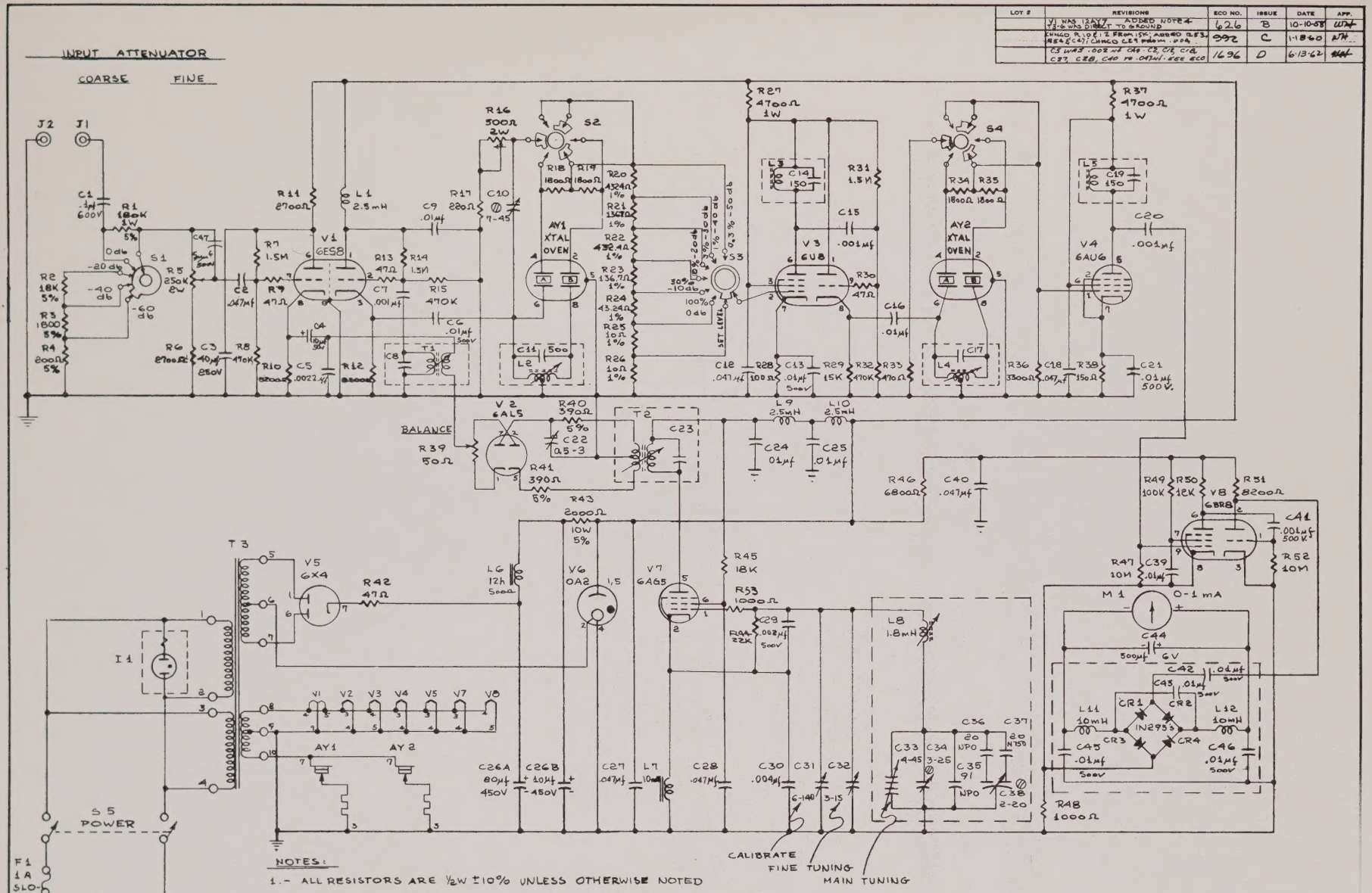
PARTS LIST - MODEL 2102 WAVE ANALYZER

NOTE: This list describes all electrical parts which are not definitively identified on the schematic diagram.

Detail No.	Description	Mfr. & No.	Donner No.
AY-1, AY-2	Crystal Assembly	per Donner Dwg. 966	Y-0002
Capacitors (excluding paper types)			
C6, C16, C42 C43, C45, C46, C21	Ceramic disc .01 mf., 500 V	Sprague 29C186	C-0029
C7, C15, C20 C41	Ceramic disc .001 mf, 500 V	Centralab DD-102	C-0028
C10	Ceramic trimmer 7-45 mmf.	Centralab 822BN	C-0126
C22	Ceramic trimmer 0.5-3 mmf.	Erie 680003	C-0285
C29	Silver mica .002 mf 500 V	Sangamo CR-1220	C-0019
C30	Silver mica .004 mf, 500 V	Sangamo CR-1240	C-0006
C31	Variable air dielectric 6-140 mmf.	Hammarlund HF-140	C-0131
C32	Variable air dielectric 3-15 mmf.	Hammarlund HF-15	C-0130
C33	Variable air dielectric 4-45 mmf.	Hammarlund VU-45	C-0132
C34	Variable air dielectric 3-25 mmf.	Hammarlund APC-25	C-0127
C35	Ceramic, tubular 91 mmf., 500 V, NPO	Erie Resistor Corp. TCO-91	C-0175
C36	Ceramic, tubular 20 mmf., 500 V, NPO	Erie Resistor Corp. TCO-20	C-0262
C37	Ceramic, tubular 20 mmf., 500 V, N750	Erie Resistor Corp. TC7-20	C-0263
C38	Variable, air dielectric differential type 2.2-21.5 mmf.	Hammarlund MAC-20	C-0266
C44	500 mf., 6 V	Sprague TVA-1103	C-0067
C47	Ceramic disc, 5 mmf. 500 V	Electra 8C050DA6	C-0290
Fuse			
F1	Fuse, 3AG, 1 amp SLO BLO	Littelfuse 313001	F-0005
Inductors			
L1, L9, L10	R.F. choke, 2.5 mh w/air core	Carad 22	L-0004
L2 (w C11) L4(w C17)	2 pi windings, 320 microamp ass'y	Donner Dwg. 4066	L-0013
L3 (w C14) L5 (w C19)	3 pi windings, 1.2 mh ass'y	Donner Dwg. 4067	L-0014

Parts List

Detail No.	Description	Mfr. & No.	Donner S/N
L6	Filter choke, 12h, 70ma	Triad #14509	L-0006
L7, L11, L12	R.F. choke, 10mh	Carad No. 23	L-0003
L8	4 pi windings 1.8 mh, ass'y.	Donner Dwg. 4057	L-0015
M1	Meter, 0-1 ma DC	Phaostron Prestige per Donner Dwg. 4043	M-0006
Resistors			
R5	Potentiometer (see S1)		
R16	Potentiometer, 500 ohms	per Donner Dwg. 100	R-0094
R20	4324 ohms, 1%	Continental Carbon type NA-15	R-0308
R21	1367 ohms 1%	"	R-0309
R22	432.4 ohms, 1%	"	R-0310
R23	136.7 ohms, 1%	"	R-0311
R24	43.24 ohms, 1%	"	R-0312
R25, R26	10 ohms, 1%	"	R-0313
R39	Potentiometer, 50 ohms	per Donner Dwg. 100	R-0097
R43	2 K, 10w, 5%	Lectrohm PT-10	R-0604
Switches			
S1 (w R5)	Rotary, 1P, 4 pos. (w 250K pot.)	per Donner Dwg. 4021	S-0018
S2, S4	Rotary, 3P, 2 pos.	per Donner Dwg. 910	S-0020
S3	Rotary, 1P, 7 pos.	per Donner Dwg. 909	S-0019
S5	Toggle, DPST	Cutler-Hammer 8360K8	S-0009
Transformers			
T1 (w C8)	Tuned R.F.	per Donner Dwg. 4065	T-0038
T2 (w C23)	Tuned R.F. center-tapped	per Donner Dwg. 4064	T-0039
T3	Power	Osborne #5317	T-0028



LOT #	REVISIONS	ECO NO.	ISSUE	DATE	APP.
	V1 WAS 12AY7 ADDED NOTE 4 V3-6 WAS DIRECT TO GROUND	626	B	10-10-58	WH
	CHNGD R 10 & 12 FROM 15K; ADDED R53, R54 & C47; CHNGD C29 FROM .004	992	C	1-18-60	WH
	C5 WAS .002 μf ON C2, C6, C26, C27, C28, C40 TO .047μf SEE ECO	1696	D	6-13-62	

DATE 5.22.58	UNLESS SPECIFIED, DIMENSIONS: INCHES TOLERANCES: FRACTIONAL ± 1/64 DECIMAL ± .005 ANGULAR ± ½°				
DRAWN [illegible]					
CHECKED WSH					
APPROVED [illegible]					
SCALE: N S	DET. NO.	ITEM	SIZE & MATERIAL OR DWG. NO.	STOCK NO.	QTY.
PART OF:					

DONNER SCIENTIFIC COMPANY

MODEL	TITLE	DRAWING NO.	ISSUE
2102	SCHEMATIC WAVE ANALYZER	4024	D

DONNER

DIVISION OF SYSTRON-DONNER Corporation

888 GALINDO STREET
CONCORD, CALIFORNIA

Phone: MUlberry 2-6161 Cable: DONNER